NAVY DEPARTMENT

THE DAVID W. TAYLOR MODEL BASIN

Washington 7, D.C.

FATIGUE TESTS OF GROUSERS FOR AMPHIBIAN TRACTORS

by

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INTRODUCTION

The amphibian tractor, or LVT, runs on an endless track having cleats, or grousers, to dig into the ground or push against the water. These grousers, shown in Figure 1, are weldments, the web being welded to the base plate which is, in turn, bolted to the drive chain. In service the welds of the grousers were cracking under fatigue loads. The David Taylor Model Basin was asked to test several designs under a bending fatigue loading which would give the same type of failure as that occurring in the field (1)(2).* Four different basic designs made up in cast and welded steel and in cast aluminum were tested to determine the design and material which had the greatest resistance to fatigue failure.

TEST PROCEDURE

When the problem of fatigue testing of LVT grousers was presented to the Taylor Model Basin, one of the first steps was to build cardboard models of the four designs shown in Figure 3 in order to give a visual, qualitative answer to the mode of behavior of the designs under load. It was found from these models that the straight web of Designs D and E increased the stiffness of the grouser.

The loading requested by the Bureau of Ships was a simple support at the two ends of the grouser with a more or less concentrated load in the center, i.e., the load was spread over 1 1/2 inch of the length; see Figure 4.

By the use of Stresscoat, it was found that, with this loading, the region of highest stress occurred in the weld at the center of the grouser. Preliminary fatigue tests also produced cracks in the weld at this point, simulating the failures obtained under service conditions on LVT's; see Figure 2.

The loading described above may not simulate the loading experienced in the field, but representatives of the Bureau of Ships concurred in the belief that this loading would permit a fair comparison of the various designs, as it provided a failure similar to the failure obtained in service.

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* Numbers in parentheses indicate references on page 3 of this report.

It was requested (1) that the grousers be tested to a reasonable number of cycles of load application, and the maximum number of cycles to which any specimen would be subjected was set at 500,000. This number of cycles is small compared with the usual fatigue limits. However, as the machine used for these tests was of relatively slow speed, it was felt that a greater number of cycles would extend the duration of the tests beyond a reasonable length of time.

The machine used to apply the fatigue loading to the grousers was an alternating-load machine with a capacity of 150,000 pounds built by the Baldwin-Southwark Corporation. This machine, pictured in Figure 5, was rather large for this task, but it was the only fatigue machine available at the Taylor Model Basin. In this machine an electric-motor drive operates a cam which applies load through a mechanical lever system. The load indicator on the machine is mechanical.

This mechanical load indicator has only one range, and the smallest division on the dial is 500 pounds. As most of the loads applied in these tests were too small to be measured accurately by this load indicator, three auxiliary means were used. The load-deflection curve of grousers of Designs A and B could be accurately determined under static loads in the 30,000-pound Baldwin-Southwark testing machine, the deflections being measured with a 1/1000-inch dial gage. When this load-deflection curve had been determined statically, the grousers were transferred to the alternating-load machine where the required load was applied by setting the machine to produce the proper amount of deflection of the grouser as determined from the static calibration.

The load-deflection curves for Designs D and E could not be determined accurately in the manner described above since these grousers were relatively stiff. To obtain a more accurate measurement of the loads, it was necessary to mount SR-4 strain gages on the web of the grousers and calibrate the strain in the gage against applied load.

When the tests were approximately half completed, a method was devised for mounting a 1/10,000-inch dial gage in place of the load indicator on the testing machine; in this way more accurate readings were obtained from the mechanical weighing device on the alternating-load machine. This more sensitive dial indicator was calibrated by applying a static load to the machine by means of a hydraulic jack and measuring the load with a TMB ring dynamometer. This method proved very satisfactory and gave accurate measurement of the applied load.

The grousers were tested in pairs, as shown in Figure 4. The simple supports at the ends were provided by steel columns with doweled ends that fit into the bolt holes of the grousers. The load was applied to the center of the grouser base plate by the loading head.

The speed of testing was 100 cycles per minute, except in the tests of cast-aluminum grousers, Design E. In these tests the speed was 300 cycles per minute at a load of 20,000 pounds and 200 cycles per minute at a load of 10,000 pounds.

TEST RESULTS

The results of the fatigue tests are shown in Table 1. Table 2 gives the relative order of merit of the grousers under the conditions of this test. New specimens were used for each test.

The locations of the failures in the various designs of specimens are shown in Figure 6.

DISCUSSION OF TEST RESULTS

The results of these tests provide a comparison of the relative merits of several grouser designs under a fatigue bending load as was applied in the laboratory. The conclusion that the best grouser in this series of tests is the one that will serve best in the field cannot be drawn, unless the loading condition in the laboratory can be shown to approximate service loading. However, the fact that failures in service and in the laboratory tests occurred at the same place on the one type of specimen where such a comparison was possible indicated that the bending load as applied in the laboratory tests was probably also predominant under service conditions.

CONCLUSIONS

Under the bending load as applied in these tests the aluminum grousers, Designs D and E, are far superior to any of the steel grousers in resistance to fatigue and also represent a weight saving of more than 2 1/4 pounds per grouser over the original welded design, Design A.

REFERENCES

(1) BuShips ltr LVT(FMC)/S-(96)-3(692-334) of 18 May 1945 to TMB.

(2) Conference in June 1945 between A.G. Bissell of BuShips and H.R. Thomas of TMB.

TABLE 1

Types and Weights of Grousers and Fatigue Data

Design	Material	Brinell Hardness	Method of Fabrication	Grouser Weight pounds	Load pounds	Cycles at Failure
A	Steel	375-429	Welded: Electrode #1 Murex #90	7.73	3,000 2,000	240,000 *
A	Steel	375-429	Welded: Electrode #2 A.W. 2C(P&H)	7.73	4,000 3,000 2,000	100,000 311,000 *
A	Steel	375-429	Welded: Electrode #3 P.F. (P&H)	7.73	4,000 3,000	136,000 *
A	Steel	375-429	Welded: Electrode #4 G. 213 (McKay)	7.73	10,000 6,800 4,000 3,000	4,000 5,000 345,000 *
A	Steel	375-429	Welded: Electrode #5 710(McKay Pluralloy)	7.73	10,000 4,000 3,000	4,000 213,000 *
A	Steel	375-429	Welded: Electrode #6 16 (McKay)	7.73	6,800 4,000 3,000	12,000 100,000 *
A	Steel	255-320	Cast	7.38	3,000 2,000 1,000	116,000 247,000 *
A	Steel	320-370	Cast	7.38	3,000 2,000	102,700 *
A	Steel	370-430	Cast	7.38	Tests on these specimens were cancelled.	
B	Steel	255-320	Cast	6.89	4,000 3,000 2,000	137,000 437,000 *
B	Steel	320-370	Cast	6.89	3,000 2,000	325,000 *
B	Steel	370-430	Cast	6.89	3,000 2,000	200,000 *
D	Steel	255-320	Cast	7.20	5,400 4,500	339,000 *
D	Steel	320-370	Cast	7.20	5,400 3,300 2,100	184,000 187,000 *
D	Steel	370-430	Cast	7.20	5,400 3,300 2,100	72,000 187,000 *
E	Steel	255-320	Cast	6.79	5,000 4,000 3,000	383,000 472,000 *
E	Steel	320-370	Cast	6.79	5,000 4,000	474,000 *
E	Steel	370-430	Cast	6.79	5,000 4,000	353,000 *
D	Aluminum		Cast	5.26	24,000 10,000	46,000 *
E	Aluminum		Cast	5.38	20,000 10,000	18,000 194,000

* Specimen had not failed at 500,000 cycles.

TABLE 2

Relative Fatigue Strength of Grousers

Design	Material	Brinell Hardness	Type of Electrode	Method of Manufacture	Load pounds	Cycles at Failure
D	Aluminum	72		Cast	24,000 10,000	46,000 no failure at 423,000
E	Aluminum	89		Cast	20,000 10,000	18,000 194,000
D	Steel	255-320		Cast	5,400 4,500	339,000 *
E	Steel	320-370		Cast	5,000 4,000	474,000 *
E	Steel	370-430		Cast	5,000 4,000	353,000 *
E	Steel	255-320		Cast	5,000 4,000 3,000	383,000 472,000 *
A	Steel	375-429	4	Welded	10,000 6,800 4,000 3,000	4,000 5,000 345,000 *
A	Steel	375-429	5	Welded	10,000 4,000 3,000	4,000 213,000 *
A	Steel	375-429	3	Welded	4,000 3,000	136,000 *
A	Steel	375-429	6	Welded	6,800 4,000 3,000	12,000 100,000 *
B	Steel	255-320		Cast	4,000 3,000 2,000	137,000 437,000 *
B	Steel	320-370		Cast	3,000 2,000	325,000 *
A	Steel	375-429	2	Welded	4,000 3,000 2,000	100,000 311,000 *
A	Steel	375-429	1	Welded	3,000 2,000	240,000 *
B	Steel	370-430		Cast	3,000 2,000	200,000 *
D	Steel	320-370		Cast	5,400 3,300 2,100	184,000 187,000 *
D	Steel	370-430		Cast	5,400 3,300 2,100	72,000 187,000 *
A	Steel	320-370		Cast	3,000 2,000	102,700 *
A	Steel	255-320		Cast	3,000 2,000 1,000	116,000 247,000 *

* Specimen had not failed at 500,000 cycles.

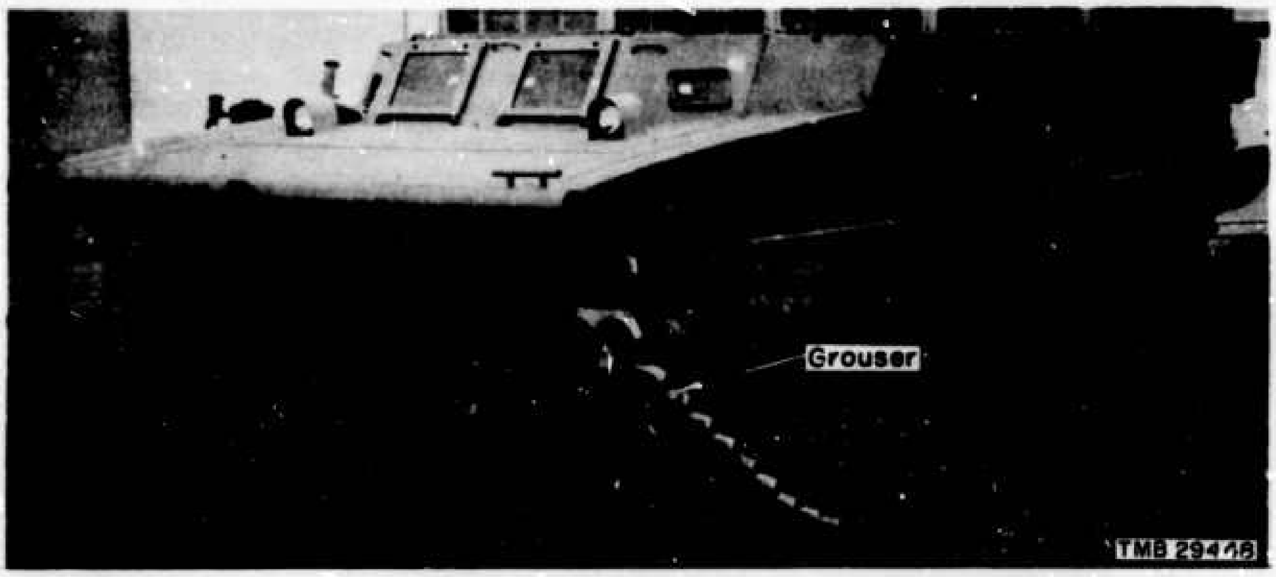

Figure 1 - Photograph of Amphibian Tractor Showing Grousers

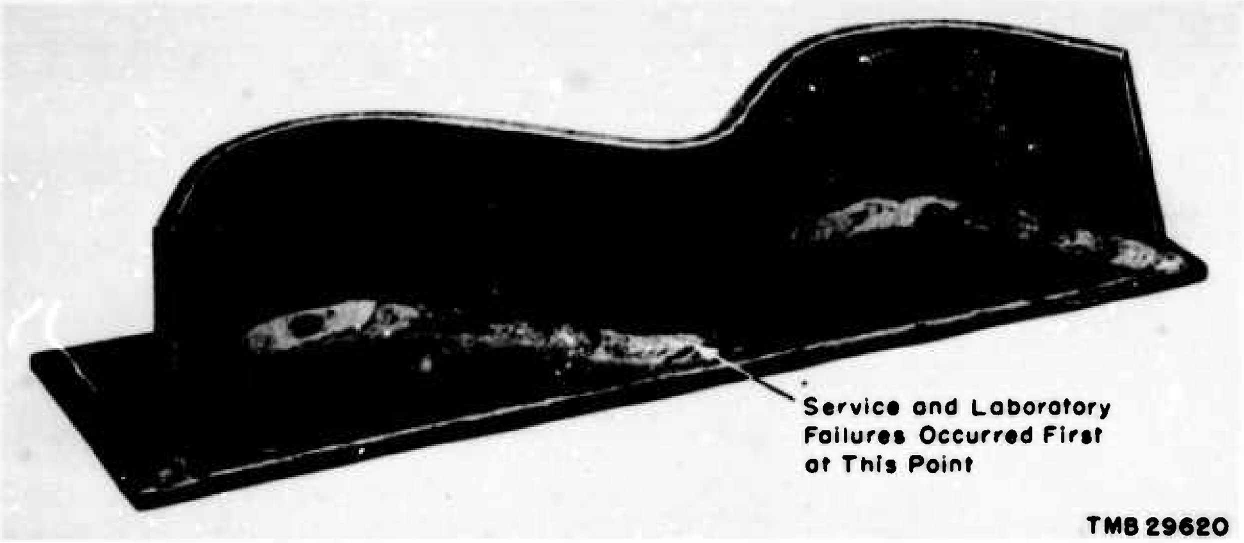

Figure 2 - Location of Failure in Welded Steel Specimen, Design A

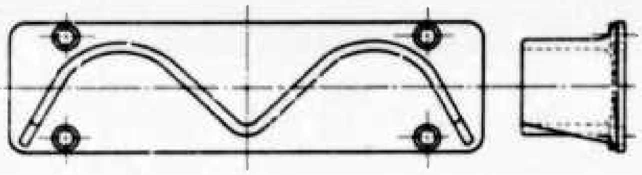

Figure 3a - Design A

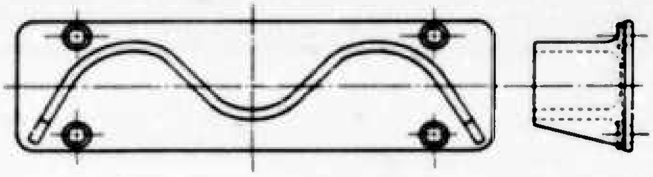

Figure 3b - Design B

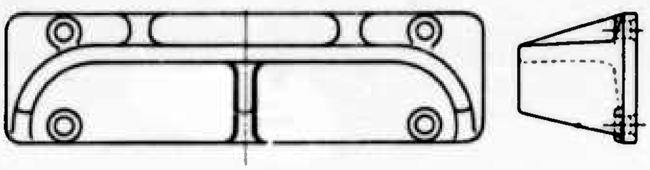

Figure 3c - Design D

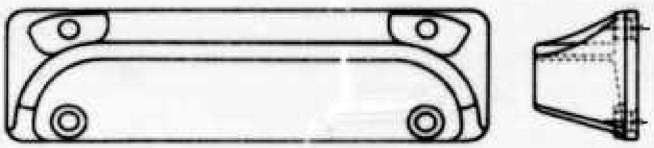

Figure 3d - Design E

Figure 3 - Sketches of the Four Grouser Designs
Tested at the Taylor Model Basin

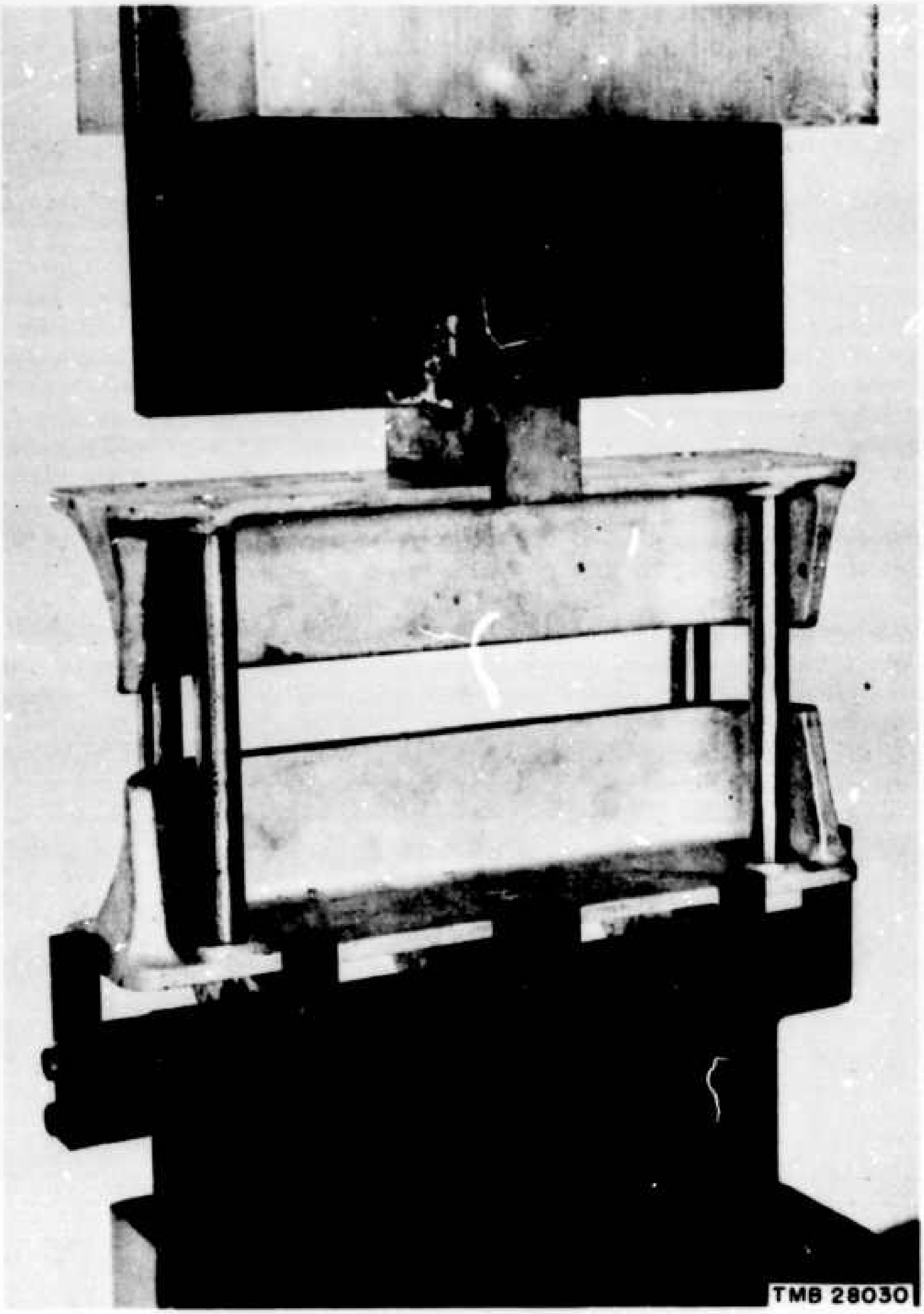

Figure 4 - Grousers Mounted for Testing in Alternating-Load Machine

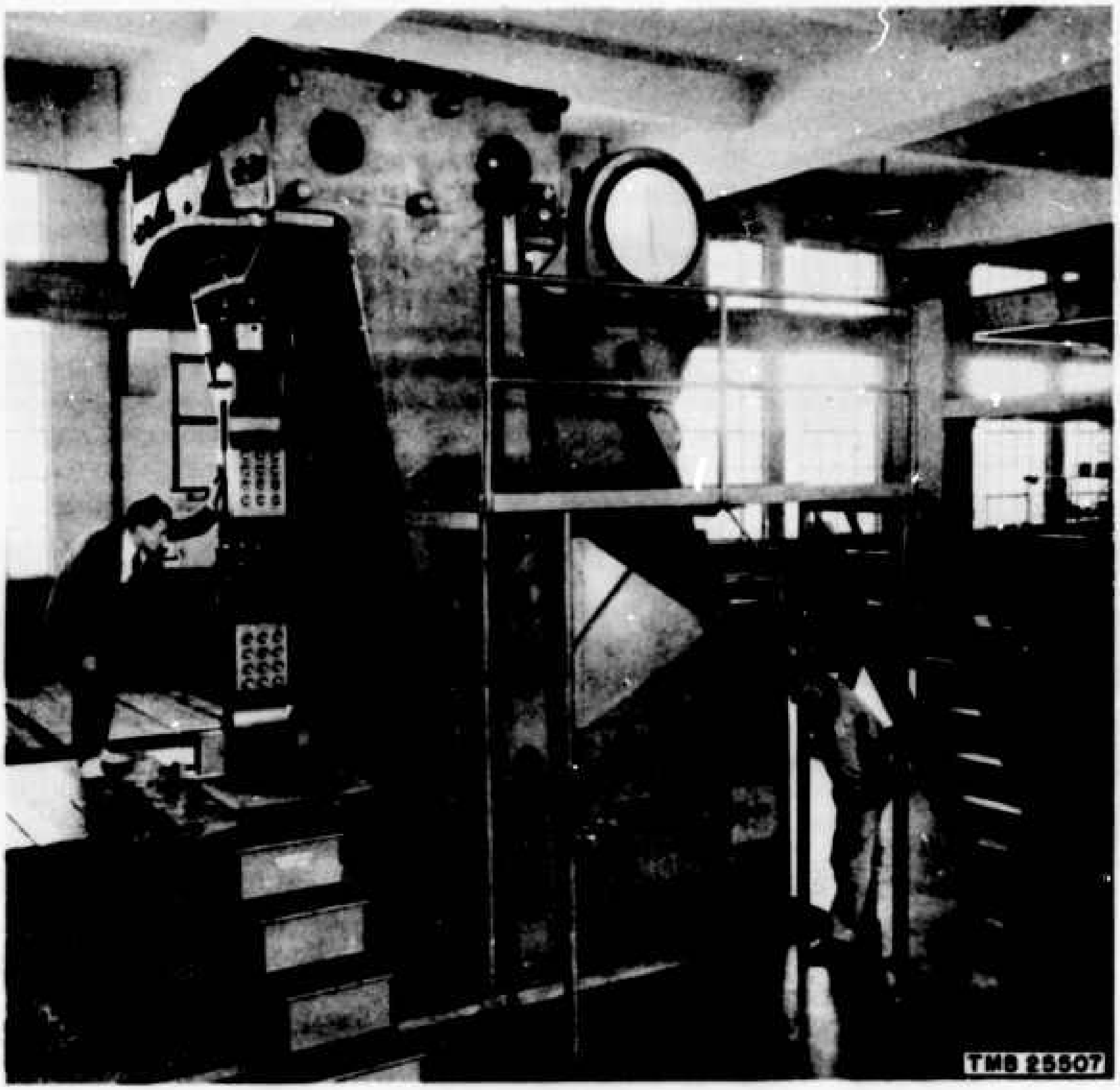

Figure 5 - Alternating-Load Machine

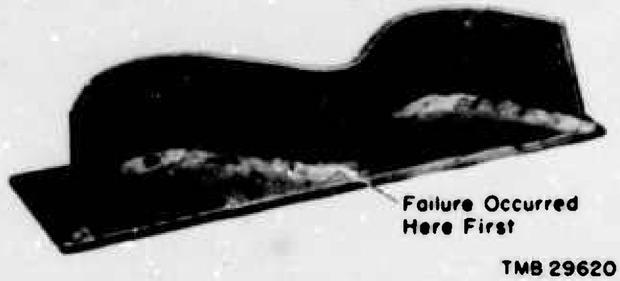

Figure 6a - Design A, Welded Steel

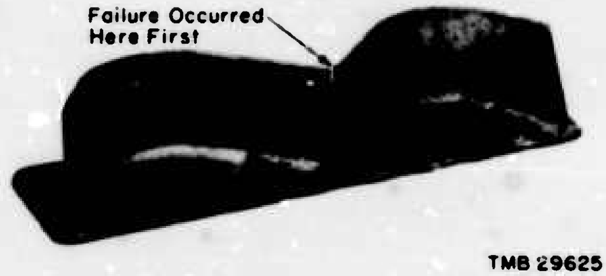

Figure 6b - Design A, Cast Steel

Figure 6c - Design B, Cast Steel

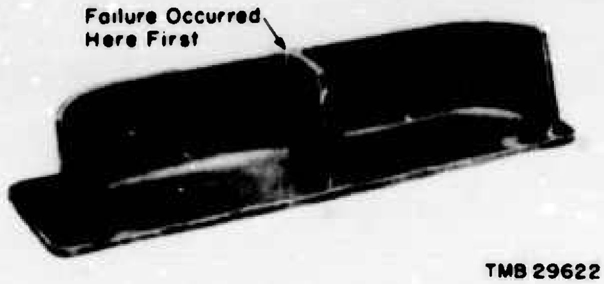

Figure 6d - Design D, Cast Steel

Figure 6e - Design E, Cast Steel

Figure 6f - Design D, Cast Aluminum

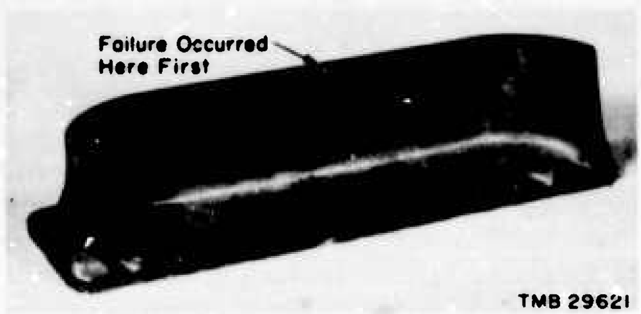

Figure 6g - Design E, Cast Aluminum

Figure 6 - Locations of Failures